

# Endemic Amphibians and Their Distribution in China

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**Abstract** Amphibians are good indicators of ecosystem health. Updating the information of endemic species in time and understanding their spatial distributions are necessary for the development of integrative conservation strategies and the elucidation of geographic patterns of amphibians. We analyzed the diversity and distributions of the endemic amphibians in China based on a database of specimen records, recently published literature, and field surveys. Two hundred and sixty two endemic species of amphibians, belonging to 59 genera in 12 families and two orders, are recognized. They account for 67% of the total number of amphibian species in China, with the family Megophryidae possessing the largest number of endemics. There are also 17 genera endemic to China. Across provinces, the species richness of endemics shows five levels with a hierarchical diversification. Sichuan has the largest number of endemics, while Heilongjiang and Jilin have no endemic species. Alternatively, whether on the level of endemic genus or species, the highest diversity occurs in the Western Mountains and Plateau Subregion. The distribution ranges of most endemic species cover  $\leq 4$  provinces or zoogeographic subregions. Additionally, the species richness of endemics along an elevational gradient shows a bell-shaped pattern with the peak around 800 m. Most endemic species are distributed in areas of low to mid elevation (c. 700–1 500 m), while 36 species are distributed up to 3 000 m. Endemic species richness decreases with increasing of elevation range. Species at mid elevations display large range sizes, while species at lower and higher elevations exhibit smaller ranges. Our results are to be beneficial for further exploration of the underlying mechanisms of distributional patterns of amphibians in China. This study highlights a need to promote conservation programs for Chinese endemic amphibians due to their narrow distribution ranges and potential threats.

**Keywords** amphibian diversity, conservation, distribution pattern, elevational gradient, endemic species

## 1. Introduction

Amphibians, considered good indicators of ecosystem health, are experiencing population declines and many are approaching extinction globally and rapidly (Stuart *et al.*, 2004; Wake and Vredenburg, 2008). Threats contributing to the decline include habitat loss, alien species, over-exploitation, global climate change, environmental chemicals and emerging infectious diseases (Collins and Storfer, 2003; Xie *et al.*, 2007). At least 43.2% of amphibian species have experienced some form of population decrease between 1980 and 2004, compared to the 27.2% which have remained stable and only 0.5% which have experienced an increase (Stuart *et al.*, 2004).

Endemic species are those entirely restricted to a specified region and, on average, usually possess a narrower geographic range than for a given taxonomic group (Laffan and Crisp, 2003). It has been suggested that such species have a high risk of extinction by chance alone (Gaston, 1994; Myers *et al.*, 2000), as they are confined to limited geographic ranges and their localized habitats are easy perturbed or destroyed, or they tend to be scarce within their ranges (Brooks *et al.*, 2002; Zhang, 2011). Thus, they become one of the most effective surrogates for identifying conservation priorities or hotspots, and should be urgently targeted for conservation, management and exploration of the underlying mechanisms of biogeographic patterns (Myers *et al.*, 2000; Sodhi *et al.*, 2008; Hu *et al.*, 2011).

Endemic species (hereafter endemics) are not randomly distributed within their distribution ranges, but are often agglomerated in specific regions or habitats (Kluge and Kessler, 2006). Due to their spatial distributions being

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important to our understanding and conservation of biodiversity, it has become a critical issue to analyze species richness and endemism using observational and specimen data (Myers *et al.*, 2000; Crisp *et al.*, 2001; Hopper and Gioia, 2004; Hu *et al.*, 2011). Additionally, the formation of endemics is complicated and closely related to geology, climate, and the process of bio-evolution. Therefore, studies on endemics and their distribution patterns are of great importance to learn about the traits, components, origin and evolution of the local fauna, and are also critical in studies of biodiversity and conservation (Jiang, 1997).

China is considered as one of the important biodiversity centers in the world (Myers *et al.*, 2000; Zhang, 2011). With its large area, diversified topography, and varied climates and habitats, China has a high degree of species diversity and endemism (Xie *et al.*, 2007; Zhang, 2011). However, percentages of vertebrate endemics in China are uneven across taxonomic groups (Fei *et al.*, 2010a; Zhang, 2011). In contrast with the endemism levels of about 8% in birds (Lei *et al.*, 2003) and about 18% in mammals (Smith and Xie, 2008), current knowledge points to higher level of amphibian endemism with 63% (Jiang *et al.*, 2010). Moreover, most endemic amphibians are rare and endangered or with great significance in phylogeny and systematics (Xie *et al.*, 2007; Fei *et al.*, 2010b; Hu *et al.*, 2011). Chen *et al.* (2008) also indicate that amphibians seem to be a better indicator of zoogeographic division than either mammals or birds.

Taxonomic revision and recognition of new species of amphibians has occurred substantially in China (e. g., Fei *et al.*, 2010b; Nishikawa *et al.*, 2011a, b; Yang *et al.*, 2011). Presently, 389 amphibian species are recognized in this country, belonging to 78 genera in 13 families and three orders (Jiang *et al.*, 2010; Hu and Jiang, unpublished data). The importance of endemic amphibians to planning the conservation of biodiversity has been emphasized (Xie *et al.*, 2007; Fei *et al.*, 2010a). Although previous studies related to endemic amphibians in China are scatteredly mentioned in literature (e. g., Xie *et al.*, 2007; Fei *et al.*, 2010a; Zhang, 2011), endemism has not been spatially explored in any detail at the national scale (Jiang *et al.*, 2010), except for regional amphibians (Fu *et al.*, 2006). Moreover, endemic species numbers have been underestimated in these studies due to the omission of some species and recognition of new species after being published and the inconsistent opinions in validity of some species among herpetologists. To understand the diversity and spatial distributions of the endemic

amphibians in China, we aim to: 1) revise the checklist of endemic amphibians, 2) reveal their geographic distributions at a regional scale (i. e., administrative provinces and zoogeographic realm), and 3) document the elevational patterns of species richness. Our study will not only help to understand the general mechanisms for distributions of Chinese endemic amphibians, but also guide conservation planning for these endemics.

## 2. Methods

**2.1 Database** Although it is difficult to estimate the exact geographic range of a single species, we can confirm the provinces or zoogeographic realms where amphibians species occur. We generated a spatial database of the distribution of endemic amphibians in China as the basis for this study. Data on geographic distributions were obtained from the following sources: 1) specimen records from museums, mainly the Herpetological Museum of Chengdu Institute of Biology (CIB), Chinese Academy of Sciences (CAS); 2) amphibian and/or herpetological fauna (Fei *et al.*, 2006, 2009a, b; Yang and Rao, 2008; Shi *et al.*, 2011); 3) herpetological monographs and current literature (Zhao and Adler, 1993; Nishikawa *et al.*, 2009, 2011a, b; Fei *et al.*, 2010a; Yang *et al.*, 2011); and 4) the results of our field surveys during the 1970s–2000s by the members of the Evolution and Biodiversity Conservation Research Group of CIB, CAS. Species taxonomy mainly followed Fei *et al.* (2006, 2009a, b, 2010a, b) and partially followed Frost (2011). The recent changes in the classification of amphibians based on phylogenetic relationships were fully considered and some modifications were made (Jiang *et al.*, 2010).

We recognized endemics referenced in Fei *et al.* (2006, 2009a, b, 2010a) and Frost (2011), which represents those only known to occur in China until now. The data of elevational distributions (minimal and maximal elevation of occurrences) for each species were compiled through an exhaustive search of the primary literature and museum collections, and complemented with field records.

**2.2 Statistical analysis** The map of China (1:4 000 000) was digitized to produce a geographic units (provinces) map using ArcGIS 9.2 (ESRI, Redland, USA). It was then overlaid with distribution maps to determine the distributions of endemics in each province. Because most records of endemics were documented for provinces but not for municipality cities and special administrative regions, we incorporated Tianjin and Beijing into Hubei Province, Shanghai into Jiangsu Province, Chongqing

into Sichuan Province, and Hongkong and Macao into Guangdong Province when analyzing. China covers parts of the Oriental and Palearctic zoogeographic realms, including seven regions: Northeastern Region, Northern China Region, Inner Mongolia-Xinjiang Region, Qinhai-Xizang Region, Southwestern Region, Central China Region and Southern China Region. As each of these regions consists of 2–5 subregions (Zhang, 2011), we compiled the species richness for each subregion. Additionally, we considered a species to have a narrow distribution if its range covers  $\leq 4$  provinces or subregions, while a wide distribution was considered to be one that covers  $\geq 4$  provinces or subregions (Jiang *et al.*, 2010).

To examine the relationship between species richness of amphibians and elevation, we divided the elevation into 100 m bands and calculated the number of species in each band. The mean and the difference between the minimum and maximum elevations of occurrence reported for each species were used to represent its elevational midpoint and breadth. To overcome statistical non-independence of the spatial data, we used the ‘midpoint method’ as a measure of the central tendency (Hu *et al.*, 2011). We explored the relationships between the species richness of endemics and their altitudinal ranges using the simple ordinary least squares (OLS) model by Origin 7.5 (OriginLab Corporation, Northampton).  $P \leq 0.05$  was considered statistically significant. Furthermore, for all endemic amphibians, two-dimensional histograms were used to depict the continuous variation of elevation range profiles for range maxima (upper limit) and minima (lower limit) over 500 m intervals, and for the midpoints and range sizes over 500 m intervals along the altitudinal gradient.

### 3. Results

**3.1 Endemism of amphibians** Two hundred and sixty two endemics of amphibians are recognized, belonging to 59 genera in 12 families and two orders (On-line Appendix 1). They account for 67% of the total species of amphibians in China. Across families, Megophryidae possesses the largest number of endemics (65 species), accounting for 25% of all endemic amphibians. It is followed by Ranidae and Rhacophoridae with 64 and 33 endemics, respectively. Considering the endemics of zoogeographic realms, there are more oriental species than palearctics. 244 species are oriental, occupying 93% of all endemics, while only eight species are palearctic, and 10 species are distributed in both the Oriental Realm

and the Palearctic Realm.

There are 17 genera endemic to China, including *Batrachuperus* Boulenger, 1878; *Dianrana* Fei, Ye and Jiang, 2010; *Feirana* Dubois, 1992; *Glandirana* Fei, Ye and Huang, 1990; *Hypselotriton* Wolterstorff, 1934; *Liua* Zhao and Hu, 1983; *Liuhurana* Fei, Ye, Jiang, Dubois and Ohler, 2010; *Liurana* Dubois, 1986; *Oreolalax* Myers and Leviton, 1962; *Pachyhynobius* Fei, Qu and Wu, 1983; *Pachytriton* Boulenger, 1878; *Parapelophryne* Fei, Ye and Jiang, 2003; *Protohynobius* Fei and Ye, 2000; *Pseudohynobius* Fei and Ye, 1983; *Pseudorana* Fei, Ye and Huang, 1990; *Rugosa* Fei, Ye and Huang, 1990; and *Yerana* Jiang, Chen and Wang, 2006 (On-line Appendix 1). For these genera, 17 species are belonging to the genus *Oreolalax*, with 6 species in both *Pachytriton* and *Hypselotriton*, 5 in both *Pseudohynobius* and *Batrachuperus*, 4 in *Liurana*, 3 in *Feirana*, and 2 in both *Liua* and *Pseudorana*. The other genera are all monospecific genus.

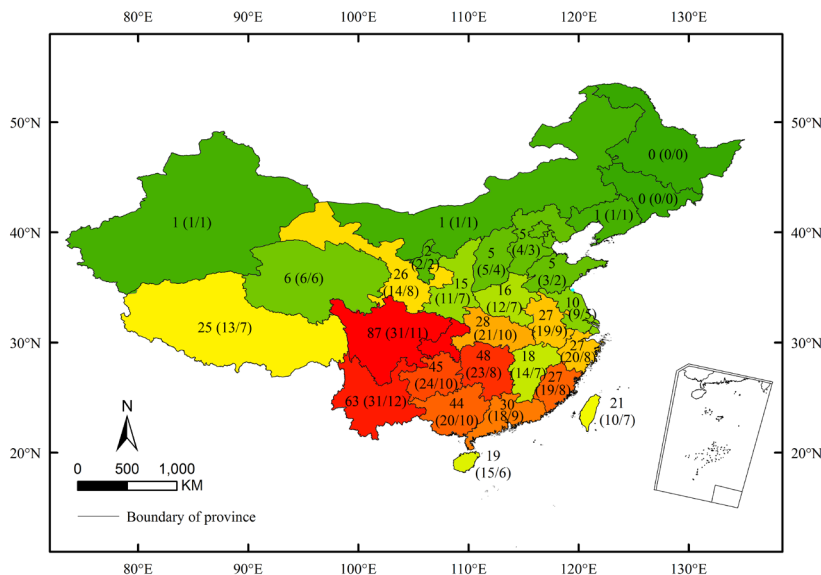
**3.2 Distribution in provinces and zoogeographic regions** The abundance of endemics in provinces can be divided into five levels with a hierarchical diversification, that is, Level I with 44–87 species, including Sichuan, Yunnan, Hunan, Guizhou and Guangxi having a higher diversity of 87, 63, 48, 45 and 44 species, respectively; Level II with 21–30 species, including Guangdong, Hubei, Fujian, Anhui, Zhejiang, Gansu, Xizang, and Taiwan; Level III with 10–19 species, including Hainan, Jiangxi, Henan, Shannxi and Jiangsu; Level IV with 1–6 species, including Qinghai, Hebei, Shandong, *et al.*; Level V with no endemics, including Heilongjiang and Jilin. Among the provinces in Level IV, Xinjiang, Inner Mongolia and Liaoning all have only one species of endemic amphibians (Figure 1).

At the level of genus, both Sichuan and Yunnan have the highest diversity with 31 genera. Moreover, the hierarchical order from highest to lowest for genus is Sichuan/Yunnan > Guizhou > Hunan > Hubei > Guangxi > Zhejiang..., and that for family is Yunnan > Sichuan > Guangxi > Guizhou > Hubei > Anhui > Guangdong... (Figure 1). There is no endemic amphibian family in China.

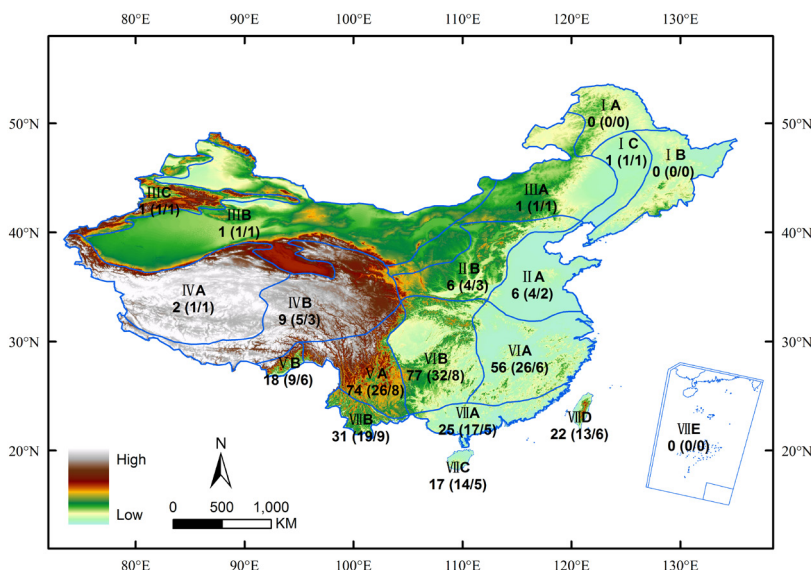
Alternatively, among zoogeographic subregions, whether at the level of genus or species, the Western Mountains and Plateau Subregion, Southwest China Mountains Subregion, and Eastern Plain and Upland Subregion have higher diversity than any of the others. In the sequence, there are 77, 74 and 56 species within these subregions, respectively. The Southern Yunnan Subregion follows with 31 species. Other subregions have

1–25 species, while the Daxing'an Mountains Subregion, Changbai Mountains Subregion and South China Sea Archipelago Subregion have no known endemics. At the level of family with endemics, the Southern Yunnan Subregion has the highest diversity, followed by the Southwest China Mountains Subregion, and Western Mountains and Plateau Subregion (Figure 2).

There are 232 (89% of the endemic amphibians in China) and 258 (98%) endemics whose distribution ranges cover  $\leq 4$  provinces and subregions, respectively. Within them, 155 and 211 species only occur in a single province or subregion. For example, *Feirana kangxianensis*, *Rana kunyuensis*, *Scutiger ningshanensis*, *Pseudepidalea taxkorensis* and *Hynobius chinensis* are



**Figure 1** Distribution patterns of endemic species of amphibians in different provinces of China. The numbers in parentheses represent, respectively, the numbers of genus and family that the endemic species belong to.



**Figure 2** The abundance of endemic species of amphibians in different zoo-geographic subregions of China. The numbers in parentheses represent, respectively, the numbers of genus and family that the endemic species belong to. I: Northeastern China Region (A: Daxing'an Mountains Subregion; B: Changbai Mountains Subregion; C: Songliao Plain Subregion); II: Northern China Region (A: Yellow River-Huai River Plain Subregion; B: Loess Plateau Subregion); III: Inner Mongolia-Xinjiang Region (A: Eastern Grass Land Subregion; B: Western Arid Subregion; C: Tianshan Mountains Subregion); IV: Qinghai-Xizang Region (A: Qiangtang Plateau Subregion; B: Qinghai-Southern Xizang Subregion); V: Southwestern China Region (A: Southwest China Mountains Subregion; B: Himalaya Mountains Subregion); VI: Central China Region (A: Eastern Plain and Upland Subregion; B: Western Mountains and Plateau Subregion); VII: Southern China Region (A: Coastal Fujian, Guangxi and Guangdong Subregion; B: Southern Yunnan Subregion; C: Hainan Island Subregion; D: Taiwan Island Subregion; E: South China Sea Archipelago Subregion). The A–E after I–VII represent subregions, following Zhang (2011).

only found in Gansu, Shandong, Shannxi, Xinjiang and Hubei, respectively. *Xenophrys huangshanensis* and *Pachytriton feii* are both only distributed in Anhui; *Echinotriton chinhaiensis*, *H. yiwuensis* and *H. amjiensis* are all only in Zhejiang; *Amolops daiyunensis*, *Odorrana huanggangensis*, *Glandirana minima* and *Hypselotriton fudingensis* only in Fujian; and more other species, such as *O. kuangwuensis*, *X. wawuensis*, and *Batrachuperus londongensis* only in Sichuan, and *H. wolterstorffi*, *Oreolalax jingdongensis*, and *Feihyla fuhua* only in Yunnan. Only six species (2%) have the ranges covering  $\geq 10$  provinces. Across provinces, 34 endemics restrict their distributions to Yunnan, followed by Sichuan with 27 species. For the endemic genera, only *Batrachuperus* and *Feirana* are distributed in the Palaearctic Realm partially and all the other genera are endemic to the Oriental Realm. Specifically, *Protohynobius*, *Parapelophryne*, *Glandirana* and *Liurana* are restricted to Sichuan, Hainan, Fujian, and Xizang, respectively (Figure 1).

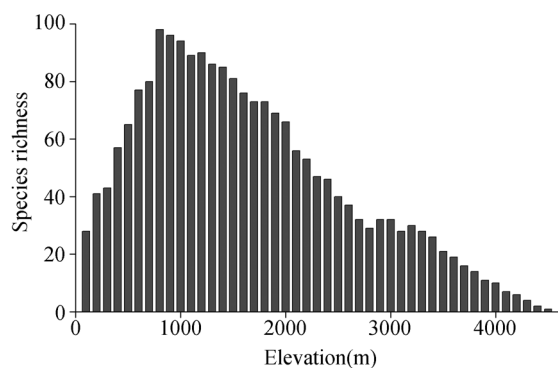
**3.3 Elevational patterns of species richness and range size** Endemic amphibians of China are distributed over a large spectrum of elevation from 0–4 500 m. The relationship between the species richness and elevational gradient shows a bell curve pattern with a normal distribution (Figure 3). Endemics increase in number steeply when elevation increases from 100 m to 800 m and then reach the peak. Whereafter, endemics decrease with the elevation increasing from 800 m to 2 800 m, and only about 30 species occur in an elevation band ranging from 2 800 m to 3 300 m. Endemics further decrease and finally only one species can be found at the elevation up to 4 500 m (Figure 3).

Seventy eight endemics (about 30% of the Chinese endemic amphibians) are distributed over large elevational ranges ( $\geq 1\ 000$  m). Among them, *Andrias davidianus*, *A.*

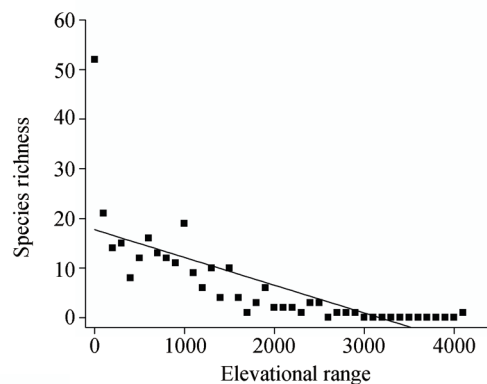
*mantzorum*, *Batrachuperus tibetanus*, *Bufo bankorensis* have elevation ranges over 2 500 m. 36 endemics (14%) are distributed at and above 3 000 m. *A. davidianus*, *B. karlschmidtii*, *B. tibetanus*, *B. yenyuanensis*, *B. tibetanus*, *Nanorana pleskei*, *N. ventripunctata*, *Scutiger glandulatus*, and *Scutiger mammatus* have the highest elevation distribution over 4 000 m. On the other hand, *Echinotriton chinhaiensis*, *Hyla zhaopingensis*, *H. yiwuensis*, *Nidirana hainanensis*, *Rana kunyuensis*, *O. macrotympa*, *Pelophylax plancyi*, *Sylvirana hekouensis* and *X. brachykolos* are typical species with low elevation ( $\leq 400$  m). The distribution patterns also show that most of the endemics occur in areas of low to middle elevations ranging from 700 m to 1 500 m.

Correlation between the richness of endemics and the elevation range is well explained by a simple ordinary least squares (OLS) model ( $R = 0.725$ ,  $P = 3.495E-8$ ; Figure 4). Additionally, the continuous variation shown by elevation range profiles can be made discrete for range maxima and minima for all endemics ending at 4 500 m (Figure 5). Most endemics (79%) are depicted as reaching their range maxima at low to middle elevation ( $\leq 2\ 500$  m), and very few surpass the elevation of 4 000 m. Ninety two endemics (35%) exhibit the combination of range maxima and minima. Relatively large numbers of endemics exclusive to highlands (the cell farthest to the right) and diminishing numbers of species that extend from highlands to lower elevation zone are clear traces of a distinctive highland amphibians. A great proportion of endemics (85%) have their lower limits below 2 000 m, while only five species are with their lower limits above 3 000 m.

The relationship between the range size and midpoint of the elevation range reveals a triangular distribution for Chinese endemic amphibians (Figure 6). The endemics at mid elevations display the complete range sizes, while

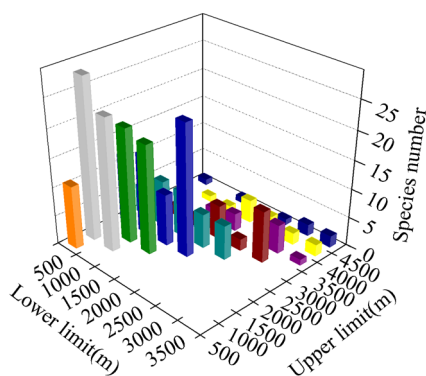


**Figure 3** The species richness of endemic amphibians along the elevational gradients in China.

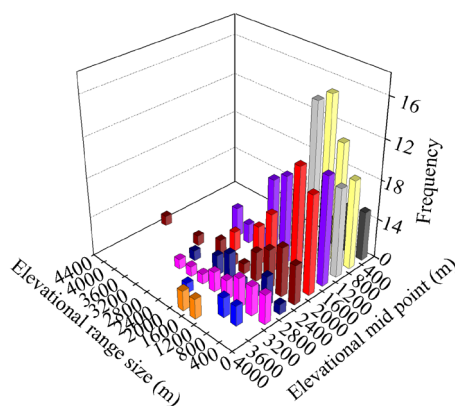


**Figure 4** Correlation scatter-plots for species richness with the elevational range for endemic amphibian species in China.

those at lower or higher elevations possess only small range sizes.



**Figure 5** Correlation scatter-plots for species richness with the elevational range for endemic amphibian species in China.



**Figure 6** Two-dimensional histograms of elevational range limits for endemic amphibian species in China. The color spectrum represents the elevational gradients.

## 4. Discussion

**4.1 Endemic amphibians and their distributions in China** Owing to the many high mountains and deep river valleys along with the diversified landforms and climates across a vast area, China has varied and complicated ecological environments, which has enabled amphibians to adapt to the diverse habitats and thus form the unique distribution patterns (Fei *et al.* 2006, 2009a, b). The identification of new species has increased the number of endemic amphibians in China over the past several decades (e. g., Zhao and Adler, 1993; Fei *et al.*, 2008; Nishikawa *et al.*, 2011b; Yang *et al.*, 2011). For example, Xie *et al.* (2007) recorded 215 species of endemic amphibians, Fei *et al.* (2010a), 233 endemics and presently we have recognized 262 endemics in China. In this study, we present the first systematic

analysis of endemic amphibians in China, which would give us a better understanding of the endemism and the distributions of amphibians in China.

Previous biogeographic studies on amphibians in China mainly focused on threatened species, diversity across all species, or elevational patterns of regional frogs (Fu *et al.*, 2006; Xie *et al.*, 2007; Jiang *et al.*, 2010). It is suggested that the level of available survey efforts, the consequent number of records available for assessment, and the identification of new species can strongly influence biogeographic assessments (Slatyer *et al.*, 2007). Molecular analyses are increasingly used in systematics and some species complexes or cryptic species are recognized (e. g., Nishikawa *et al.*, 2011b; Yang *et al.*, 2011). Concurrently, substantial field efforts for amphibians have been launched in recent years in China. Such efforts have dramatically increased the records available for analyzing the distributions of amphibians and providing information of unsurveyed or poorly surveyed areas. Jiang *et al.* (2010) indicated that the greatest species richness occurred in the family Ranidae, followed by Megophryidae. However, in this study, Megophryidae is found with the largest number of endemics, and Ranidae is the second. This discrepancy may be due to the different distribution characteristics between these two families: the proportion of species with narrow distributions in the Megophryidae is higher than that in the Ranidae. Among provinces, Sichuan is shown to have the largest number of threatened amphibians (Xie *et al.*, 2007) and endemic birds (Lei *et al.*, 2003), while Heilongjiang and Jilin are located in the region of low species diversity (Xie *et al.*, 2007). This pattern is coincident with that of endemic amphibians uncovered here.

We can define the endemics which are limited to small, narrow regions or in discontinuous regions as species with regional or discontinued distributions (Lei *et al.*, 2003). For example, *O. jingdongensis* is only distributed in Jingdong, Shuangbai, and Xiping counties of Yunnan, even if there are wide similar habitats around their known distribution sites (Fei *et al.*, 2009a). The difference between the ‘actual distribution areas’ and ‘potential distribution areas’ may inevitably occur (Hu and Jiang, 2010). Except for some determined new differentiation patterns, the explanation for the locally distributed endemics is mostly human activities or that the species are at a natural decline state (Hu and Jiang, 2010; Zhang, 2011). Additionally, the isolated discontinuous distribution is also a normal phenomenon of local distribution. For example, *H. orientalis* is widely

distributed from eastern coastal to the central mainland of China, but its congener, *H. chenggongensis*, can only be encountered in Chenggong County, Yunnan (Fei *et al.*, 2006; 2010a). Another example is the genus *Feirana*. *F. quadranus* is widely distributed in the Wuling Mountains, Daba Mountains, Shennongjia, Longmen Mountains, and the central and western Qinling Mountains, while *F. taihangnica* in the central and eastern Qinling Mountains, Zhongtiao Mountains, and southern Taihang Mountains (Wang *et al.*, 2009; Yang *et al.*, 2011; Hu and Jiang, unpublished data). The central Qinling Mountains are suggested as the sympatric areas between these two species of *Feirana* (Wang *et al.*, 2009). However, *F. kangxianensis*, which is closely related to *F. taihangnica*, is currently known to only occur in Kangxian County, Gansu, and is discontinuously distributed in those areas of *F. taihangnica* (Yang *et al.*, 2011). The mainland, Taiwan Island and Hainan Island of China have similar or related species, which are also discontinuously distributed with a representative example of the genus *Hynobius*. *H. arisanensis*, *H. formosanus*, *H. fuca*, *H. glacialis*, and *H. sonani* are endemic to Taiwan Island, while *H. amjiensis*, *H. guabangshanensis*, *H. maoershanensis*, and *H. yiwuensis* occur in Anji County of Zhejiang, Qiyang County of Hunan, Longshen and Xing'an counties of Guangxi, and Zhenhai, Yiwu, Wenling, Jiangshan, Xiaoshan and Zhoushan counties of Zhejiang, respectively (Shen *et al.*, 2004; Fei *et al.*, 2006, 2010a; Zhou *et al.*, 2006; Lai and Lue, 2008). These distribution patterns may relate to the appearance of several ice ages in the Quaternary or the vicariance events (Fei *et al.*, 2006; Zeisset and Beebee, 2008).

**4.2 Elevational patterns of species richness and range size** The understanding of the distribution patterns of species richness along elevational gradients is crucial to developing a general theory on species diversity (Rowe, 2009). Our results show that the endemic amphibians in China are not evenly distributed along the elevational gradients, with the richest species being at elevations between 800–1 200 m. Looking at a wide geographic range for frog taxa, Hu *et al.* (2011) suggested that mid-elevations (around 1 500 m) in Asia are richer in endemics of spiny frogs than the lower and higher elevations. In this study, the substantial decrease of endemic amphibians towards high elevations (> 3 000 m) further supports this pattern. Similar patterns are also documented in the frogs of the Hengduan Mountains (Fu *et al.*, 2006). It can be interpreted as a reflection of the complex topographic configuration of China, where many montane habitats possess varied and complicated ecological environments.

Accumulations of endemics are likely to be found in the highly diversified habitats. This fact indicates that the amphibian community composition pattern is strongly influenced by the basins with stepped landforms (Fei *et al.*, 2009b; Zhang, 2011).

Distribution ranges of species result from complex interactions among many factors, including physiological traits, history of speciation and dispersal, and constraints from continental shape (Webb and Gaston, 2003). The fact that the richness of endemic amphibians in China decreases with increasing elevational range indicates that most endemics possess narrow elevational ranges. In particular, many endemics exhibit the combination of lower and upper limits. Here, a triangular pattern is found for the relationship between range sizes and midpoints of elevation, and species at intermediate elevations have the broadest amplitudes. The results complement other evidences showing a need for further testing the generality of the Rapoport's altitudinal effect (Patterson *et al.*, 1998; Hu *et al.*, 2011).

## 5. Conclusions

Endemism is inherently scale dependent and sensitive to the delineation of boundaries (Lomolino *et al.*, 2006). Therefore, we should delimit the distributions of endemic taxa ideally using natural and geographic boundaries rather than administrative boundaries. Moreover, two types of errors (i. e., the overweighting of the widespread species regarded in the literature but with few observational records; the erroneous records for species with narrow recorded ranges which create comparatively high endemism scores in wrong places), should be emphasized when the distributions of endemics are being interpreted (Slatyer *et al.*, 2007). Despite these issues, exploring the patterns of endemism and the distributions of endemics is important for understanding regional characters, compositions and evolutionary process of fauna, and also is of particular interest in the development of integrative conservation strategies (Jablonski, 1986; Grau *et al.*, 2007). Amphibians with restricted ranges should be urgently protected (Sodhi *et al.*, 2008). Therefore, China which is one of the countries with richest endemic species needs to pay immediate attention to conservation (Xie *et al.*, 2007). For example, it is urgently necessary to launch conservation plans urgently for *F. kangxianensis*, given its restricted distribution range and great existence risk under the pressure of intense human activities (Yang *et al.*, 2011; Hu and Jiang, unpublished data). Besides

the endemic amphibian species, there are 17 endemic genera in China with some monospecific genera. They are especially important for the evolutionary process and need conservation, because the extinction of one species means that all of the genus will disappear. Unfortunately, China's natural habitats, particularly forests, have suffered severe degradation because of increasingly intensive human activities (Xie *et al.*, 2007; Jiang *et al.*, 2010). Thus, we still use administrative boundaries to delimit endemic amphibians and refer to endemic taxa as those only occurring within China's borders. Alternatively, we can use alternative methodologies for generating distribution maps and range sizes for the endemics, such as using predictive spatial modeling which would reduce the problem of an undersampled species range (Hu *et al.*, 2010; Hu and Jiang, 2011). To be brief, this study can promote our understanding of the underlying mechanisms of distribution patterns of amphibians in China, and highlights a need to launch conservation programs for Chinese endemic amphibians due to their narrow distribution ranges and the potential threats.

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# 1 Endemic amphibians and their distribution in China

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## 5 Appendix 1

6 The catalog of endemic species of amphibians in China.

Orders	Families	Genera	Species
CAUDATA	Hynobiidae  Cope, 1859	<i>Protohynobius</i> Fei and Ye, 2000	<i>P. puxiongensis</i> Fei and Ye, 2000
		<i>Hynobius</i> Tschudi, 1838	<i>H. amjiensis</i> Gu, 1992
			<i>H. arisanensis</i> Maki, 1922
			<i>H. chinensis</i> Günther, 1889
			<i>H. formosanus</i> Maki, 1922
			<i>H. fuca</i> Lai and Lue, 2008
			<i>H. glacialis</i> Lai and Lue, 2008
			<i>H. guabangshanensis</i> Shen, 2004
			<i>H. maoershanensis</i> Zhou, Jiang, and Jiang, 2006
			<i>H. sonani</i> Maki, 1922
			<i>H. yiwuensis</i> Cai, 1985
		<i>Pachyhynobius</i> Fei, Qu, and Wu, 1983	<i>P. shangchengensis</i> Fei, Qu, and Wu, 1983
		<i>Pseudohynobius</i> Fei and Ye, 1983	<i>P. flavomaculatus</i> Hu and Fei, 1978
			<i>P. guizhouensis</i> Li, Tian and Gu, 2010
			<i>P. jinpo</i> Wei, Xiong, and Zeng, 2009
			<i>P. kuankuoshuiensis</i> Xu, Zeng, and Fu, 2007
			<i>P. shuichengensis</i> Tian, Li, and Gu, 1998
		<i>Liuia</i> Zhao and Hu, 1983	<i>L. shihi</i> Liu, 1950

Orders	Families	Genera	Species
			<i>L. tsinpaensis</i> Liu and Hu, 1966
		<i>Batrachuperus</i> Boulenger, 1878	<i>B. londongensis</i> Liu and Tian, 1978
			<i>B. pinchonii</i> David, 1872
			<i>B. karlschmidtii</i> Liu, 1950
			<i>B. tibetanus</i> Schmidt, 1925
			<i>B. yenyuanensis</i> Liu, 1950
	Cryptobranchidae Fitzinger, 1826	<i>Andrias</i> Tschudi, 1837	<i>A. davidianus</i> Blanchard, 1871
	Salamandroidae Goldfuss, 1820	<i>Tylotriton</i> Anderson, 1871	<i>T. hainanensis</i> Fei, Ye, and Yang, 1984
			<i>T. kweichowensis</i> Fang and Chang, 1932
			<i>T. taliangensis</i> Liu, 1950
			<i>T. wenxianensis</i> Fei, Ye, and Yang, 1984
		<i>Echinotriton</i> Nussbaum and Brodie, 1982	<i>E. chinhaiensis</i> Chang, 1932
		<i>Paramesotriton</i> Chang, 1935	<i>P. caudopunctatus</i> Liu and Hu, 1973
			<i>P. chinensis</i> Gray, 1859
			<i>P. fuzhongensis</i> Wen, 1989
			<i>P. guanxiensis</i> Huang, Tang, and Tang, 1983
			<i>P. hongkongensis</i> Myers and Leviton, 1962
			<i>P. labiatus</i> Unterstein, 1930
			<i>P. longliensis</i> Li, Tian, Gu, and Xiong, 2008
			<i>P. yunwuensis</i> Wu, Jiang, et. Hanken 2010
			<i>P. zhijinensis</i> Li, Tian, and Gu, 2008
		<i>Pachytriton</i> Boulenger, 1878	<i>P. archospotus</i> Shen, Shen, and Mo, 2008
			<i>P. brevipes</i> Sauvage, 1876

Orders	Families	Genera	Species
			<i>P. inexpectatus</i> Nishikawa, Jiang, Matsui et Mo, 2010
			<i>P. granulosus</i> Chang, 1935
			<i>P. feii</i> sp. nov. Nishikawa, Jiang and Matsui, 2011
			<i>P. moi</i> sp. nov. Nishikawa, Jiang and Matsui, 2011
		<i>Hypselotriton</i> Wolterstorff, 1934	<i>H. chenggongensis</i> Kou and Xing, 1983
			<i>H. cyanurus</i> Liu, Hu, and Yang, 1962
			<i>H. fudingensis</i> Wu, Wang, Jiang, and Hanken, 2010
			<i>H. orientalis</i> David, 1873
			<i>H. orphicus</i> Risch, 1983
			<i>H. wolterstorffi</i> Boulenger, 1905
ANURA	Bombinatoridae Gray, 1825	<i>Bombina</i> Oken, 1816	<i>B. fortinuptialis</i> Hu and Wu, 1978
			<i>B. lichuanensis</i> Fei and Ye, 1995
			<i>B. microdeladigitata</i> Liu, Hu and Yang, 1960
			<i>B. maxima</i> Boulenger, 1905
	Megophryidae Bonaparte, 1850	<i>Oreolalax</i> Myers and Leviton, 1962	<i>O. chuanbeiensis</i> Tian, 1983
			<i>O. granulosus</i> Fei, Ye, and Chen, 1990
			<i>O. jingdongensis</i> Ma, Yang, and Li, 1983
			<i>O. liangbeiensis</i> Liu and Fei, 1979
			<i>O. lichuanensis</i> Hu and Fei, 1979
			<i>O. major</i> Liu and Hu, 1960
			<i>O. multipunctatus</i> Wu, Zhao, Inger, and Shaffer, 1993
			<i>O. nanjiangensis</i> Fei, Ye, and Li, 1999
			<i>O. omeimontis</i> Liu and Hu, 1960
			<i>O. pingii</i> Liu, 1943
			<i>O. popei</i> Liu, 1947

Orders	Families	Genera	Species
			<i>O. puxiongensis</i> Liu and Fei, 1979
			<i>O. rhodostigmatus</i> Hu and Fei, 1979
			<i>O. rugosus</i> Liu, 1943
			<i>O. schmidtii</i> Liu, 1947
			<i>O. weigoldi</i> Vogt, 1924
			<i>O. xiangchengensis</i> Fei and Huang, 1983
		<i>Scutigera</i> Theobald, 1868	<i>S. chintingsensis</i> Liu and Hu, 1960
			<i>S. glandulatus</i> Liu, 1950
			<i>S. gongshanensis</i> Yang and Su, 1979
			<i>S. jiulongensis</i> Fei, Ye, and Jiang, 1995
			<i>S. liupanensis</i> Huang, 1985
			<i>S. maculatus</i> Liu, 1950
			<i>S. mammatus</i> Günther, 1896
			<i>S. muliensis</i> Fei and Ye, 1986
			<i>S. ningshanensis</i> Fang, 1985
			<i>S. pingwuensis</i> Liu and Tian, 1978
			<i>S. tuberculatus</i> Liu and Fei, 1979
			<i>S. wanglangensis</i> Ye and Fei, 2007
		<i>Leptobrachium</i> Tschudi, 1838	<i>L. L. guangxiense</i> Fei, Mo, Ye and Jiang, 2009
			<i>L. L. hainanense</i> Ye and Fei, 1993
			<i>L. V. boringii</i> Liu, 1945
			<i>L. V. promustache</i> Rao, Wilkinson, and Zhang, 2006
			<i>L. V. leishanense</i> Liu and Hu, 1973
			<i>L. V. liui</i> Pope, 1947
		<i>Paramegophrys</i> Liu, 1964	<i>P. alpinus</i> Fei, Ye, and Li, 1990

Orders	Families	Genera	Species
			<i>P. liui</i> Fei and Ye, 1990
			<i>P. oshanensis</i> Liu, 1950
			<i>P. ventripunctatus</i> Fei, Ye, and Li, 1990
		<i>Brachytarsophrys</i> Tian and Hu, 1983	<i>B. chuannanensis</i> Fei, Ye, and Huang, 2001
		<i>Xenophrys</i> Günther, 1864	<i>X. baolongensis</i> Ye, Fei, and Xie, 2007
			<i>X. binchuanensis</i> Ye and Fei, 1995
			<i>X. binlingensis</i> Jiang, Fei, and Ye, 2009
			<i>X. boettgeri</i> Boulenger, 1899
			<i>X. brachykolos</i> Inger and Romer, 1961
			<i>X. caudoprocta</i> Shen, 1994
			<i>X. daweimontis</i> Rao and Yang, 1997
			<i>X. gigantea</i> Liu, Hu, and Yang, 1960
			<i>X. huangshanensis</i> Fei and Ye, 2005
			<i>X. jingdongensis</i> Fei and Ye, 1983
			<i>X. kuatunensis</i> Pope, 1929
			<i>X. mangshanensis</i> Fei and Ye, 1990
			<i>X. medogensis</i> Fei and Ye, 1983
			<i>X. nankiangensis</i> Liu and Hu, 1966
			<i>X. omeimontis</i> Liu, 1950
			<i>X. pachyproctus</i> Huang, 1981
			<i>X. sangzhiensis</i> Jiang, Ye, and Fei, 2008
			<i>X. shapingensis</i> Liu, 1950
			<i>X. shuichengensis</i> Tian, Gu, and Sun, 2000
			<i>X. spinata</i> Liu and Hu, 1973

Orders	Families	Genera	Species
			<i>X. wawuensis</i> Fei, Jiang, and Zheng, 2001
			<i>X. wuliangshanensis</i> Ye and Fei, 1995
			<i>X. wushanensis</i> Ye and Fei, 1995
			<i>X. zhangii</i> Ye and Fei, 1992
			<i>X. tuberogranulatus</i> Mo, Shen, Li, et. 2010
	Bufonidae Gray, 1825	<i>Bufo</i> Garsault, 1764	<i>B. cryptotympanicus</i> Liu et Hu, 1962
			<i>B. bankorensis</i> Barbour, 1908
			<i>B. tibetanus</i> Zarevsky, 1926
			<i>B. tuberculatus</i> Zarevsky, 1926
		<i>Torrentophryne</i> Yang, 1996	<i>T. ailaoanus</i> Kou, 1984
			<i>T. aspinius</i> Rao and Yang, 1994
			<i>T. luchunnicus</i> Yang and Rao, 2008
			<i>T. menglianus</i> Yang, 2008
			<i>T. tuberospinus</i> Yang, Liu, and Rao, 1996
		<i>Ingerophrynus</i> Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006	<i>I. ledongensis</i> Fei, Ye, and Huang, 2009
		<i>Pseudepidalea</i> Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy,	<i>P. taxkorensis</i> Fei, Ye and Huang, 1999
			<i>P. zandaensis</i> Fei, Ye, and Huang, 1999

Orders	Families	Genera	Species
		Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006	
		<i>Parapelophryne</i> Fei, Ye, and Jiang, 2003	<i>P. scalpta</i> Liu and Hu, 1973
	Hylidae Rafinesque, 1815	<i>Hyla</i> Laurenti, 1768	<i>H. chinensis</i> Günther, 1858
			<i>H. gongshanensis</i> Jerdon, 1870
			<i>H. immaculata</i> Boettger, 1888
			<i>H. sanchiangensis</i> Pope, 1929
			<i>H. tsinlingensis</i> Liu and Hu, 1966
			<i>H. zhaopingensis</i> Tang and Zhang, 1984
	Ranidae Rafinesque-Schmaltz, 1814	<i>Rana</i> Linnaeus, 1758	<i>R. chaochiaoensis</i> Liu, 1946
			<i>R. chensinensis</i> David, 1875
			<i>R. chevronata</i> Hu and Ye, 1978
			<i>R. culaiensis</i> Li, Lu, and Li, 2008
			<i>R. hanluica</i> Shen, Jiang, and Yang, 2007
			<i>R. kukunoris</i> Nikolskii, 1918
			<i>R. kunyuensis</i> Lu and Li, 2002
			<i>R. longicrus</i> Stejneger, 1898
			<i>R. zhenhaiensis</i> Ye, Fei, and Matsui, 1995
			<i>R. maoershanensis</i> Lu, Li, and Jiang, 2007
			<i>R. omeimontis</i> Ye and Fei, 1993
			<i>R. sauteri</i> Boulenger, 1909
			<i>R. multidenticulata</i> Chou and Lin, 1997
			<i>R. zhengi</i> Zhao, 1999

Orders	Families	Genera	Species
		<i>Liuhurana</i> Fei, Ye, Jiang, Dubois and Ohler, 2010	<i>L. shuchinae</i> Liu, 1950
		<i>Pelophylax</i> Fitzinger, 1843	<i>P. fukienensis</i> Pope, 1929
			<i>P. hubeiensis</i> Fei and Ye, 1982
			<i>P. nigrolineatus</i> Liu and Hu, 1959
			<i>P. plancyi</i> Lataste, 1880
		<i>Dianrana</i> Fei, Ye and Jiang, 2010	<i>D. pleuraden</i> Boulenger, 1904
		<i>Rugosa</i> Fei, Ye and Huang, 1990	<i>R. tientaiensis</i> Chang, 1933
		<i>Glandirana</i> Fei, Ye, and Huang, 1990	<i>G. minima</i> Ting and T'sai, 1979
		<i>Pseudorana</i> Fei, Ye, and Huang, 1990	<i>P. sangzhiensis</i> Shen, 1986
			<i>P. weiningensis</i> Liu, Hu, and Yang, 1962
		<i>Sylvirana</i> Dubois, 1992	<i>S. bannanica</i> Rao and Yang, 1997
			<i>S. hekouensis</i> Fei, Ye, and Jiang, 2008
			<i>S. latouchii</i> Boulenger, 1899
			<i>S. menglaensis</i> Fei, Ye, and Xie, 2008
			<i>S. nigrotympanica</i> Dubois, 1992
			<i>S. spinulosa</i> Smith, 1923
		<i>Nidirana</i> Dubois, 1992	<i>N. daunchina</i> Chang, 1933
			<i>N. hainanensis</i> Fei, Ye, and Jiang, 2007
		<i>Bamburana</i> Fei, Ye and Huang, 2005	<i>B. exilversabilis</i> Li, Ye, and Fei, 2001
			<i>B. nasuta</i> Li, Ye, and Fei, 2001
			<i>B. tormota</i> Wu, 1977

Orders	Families	Genera	Species
			<i>B. versabilis</i> Liu and Hu, 1962
		<i>Eburana</i> Dubois, 1992	<i>E. swinhoana</i> Boulenger, 1903
		<i>Odorrana</i> Fei, Ye, and Huang, 1990	<i>O. anlungensis</i> Liu and Hu, 1973
			<i>O. cangyuanensis</i> Yang, 2008
			<i>O. hainanensis</i> Fei, Ye, and Li, 2001
			<i>O. hejiangensis</i> Deng and Yu, 1992
			<i>O. huanggangensis</i> Chen, Zhou and Zheng, 2010
			<i>O. kuangwuensis</i> Liu and Hu, 1966
			<i>O. lungshengensis</i> Liu and Hu, 1962
			<i>O. macrotympana</i> Yang, 2008
			<i>O. margaretae</i> Liu, 1950
			<i>O. nanjiangensis</i> Fei, Ye, Xie, and Jiang, 2007
			<i>O. rotodora</i> Yang and Rao, 2008
			<i>O. schmackeri</i> Boettger, 1892
			<i>O. wuchuanensis</i> Xu, 1983
			<i>O. yizhangensis</i> Fei, Ye, and Jiang, 2007
			<i>O. zhaoi</i> Li, Lu, and Rao, 2008
		<i>Amolops</i> Cope, 1865	<i>A. aniqiaoensis</i> Dong, Rao, and Lü, 2005
			<i>A. bellulus</i> Liu, Yang, Ferraris, and Matsui, 2000
			<i>A. daiyunensis</i> Liu and Hu, 1975
			<i>A. granulatus</i> Liu and Hu, 1961
			<i>A. hainanensis</i> Boulenger, 1900
			<i>A. hongkongensis</i> Pope and Romer, 1951
			<i>A. lifanensis</i> Liu, 1945
			<i>A. loloensis</i> Liu, 1950

Orders	Families	Genera	Species
			<i>A. mantzorum</i> David, 1872
			<i>A. medogensis</i> Li and Rao, 2005
			<i>A. torrentis</i> Smith, 1923
			<i>A. wuyiensis</i> Liu and Hu, 1975
	Dicroglossidae  Anderson, 1871	<i>Limnonectes</i> Fitzinger, 1843	<i>L. fragilis</i> Liu and Hu, 1973
			<i>L. fujianensis</i> Ye and Fei, 1994
		<i>Gynandropaa</i> Dubois, 1992	<i>G. liui</i> Dubois, 1986
			<i>G. phrynoides</i> Boulenger, 1920
		<i>Maculopaa</i> Fei, Ye and Jiang, 2010	<i>M. conaensis</i> Fei and Huang, 1981
			<i>M. maculosa</i> Liu, Hu, and Yang, 1960
			<i>M. medogensis</i> Fei and Ye, 1999
		<i>Feirana</i> Dubois, 1992	<i>F. quadranus</i> Liu, Hu, and Yang, 1960
			<i>F. taihangnica</i> Chen and Jiang, 2002
			<i>F. kangxianensis</i> Yang, Wang, Hu and Jiang, 2011
		<i>Nanorana</i> Guenther, 1896	<i>N. pleskei</i> Günther, 1896
			<i>N. ventripunctata</i> Fei and Huang, 1985
		<i>Quasipaa</i> Dubois, 1992	<i>Q. exilispinosa</i> Liu and Hu, 1975
			<i>Q. jiulongensis</i> Huang and Liu, 1985
			<i>Q. robertingeri</i> Wu and Zhao, 1995
			<i>Q. shini</i> Ahl, 1930
		<i>Yerana</i> Jiang Chen and Wang, 2006	<i>Y. yei</i> Chen, Qu, and Jiang, 2002
	Occidozygidae Fei, Ye, and Huang, 1990	<i>Taylorana</i> Dubois, 1986	<i>T. liui</i> Yang, 1983
		<i>Liurana</i> Dubois, 1986	<i>L. alpina</i> Huang and Ye, 1997
			<i>L. medogensis</i> Fei, Ye and Huang, 1997

Orders	Families	Genera	Species
			<i>L. reticulata</i> Zhao and Li, 1984
			<i>L. xizangensis</i> Hu, 1977
	Rhacophoridae Hoffman, 1932	<i>Buergeria</i> Tschudi, 1838	<i>B. oxycephala</i> Boulenger, 1900
			<i>B. robusta</i> Boulenger, 1909
		<i>Gracixalus</i> Delorme, Dubois,	<i>G. jinxiuensis</i> Hu, 1978
		Grosjean, and Ohler, 2005	<i>G. medogensis</i> Ye and Hu, 1984
		<i>Liuxalus</i> Li, Che, Bain, Zhao, and Zhang, 2008	<i>L. hainanus</i> Liu and Wu, 2004
			<i>L. ocellatus</i> Liu and Hu, 1973
			<i>L. romeri</i> Smith, 1953
		<i>Feihyla</i> Frost, Grant, Faivovich, Bain, Haas, Haddad, de Sá, Channing, Wilkinson, Donnellan, Raxworthy, Campbell, Blotto, Moler, Drewes, Nussbaum, Lynch, Green, and Wheeler, 2006	<i>F. fuhua</i> Fei, Ye and Jiang, 2010
		<i>Pseudophilautus</i> Laurent, 1943	<i>P. menglaensis</i> Kou, 1990
		<i>Kurixalus</i> Ye, Fei, and Dubois, 1999	<i>K. hainanus</i> Zhao, Wang, and Shi, 2005
			<i>K. idiootocus</i> Kuramoto and Wang, 1987
		<i>Theloderma</i> Tschudi, 1838	<i>T. baibengensis</i> Jiang, Fei, and Huang, 2009
			<i>T. kwangsiense</i> Liu and Hu, 1962
		<i>Polypedates</i> Tschudi, 1838	<i>P. impresus</i> Yang, 2008
			<i>P. spinus</i> Yang, 2008
		<i>Rhacophorus</i> Kuhl and Van Hasselt, 1822	<i>R. laoshan</i> Mo, Jiang, Xie, and Ohler, 2008
			<i>R. translineatus</i> Wu, 1977

Orders	Families	Genera	Species
			<i>R. verrucopus</i> Huang, 1983
			<i>R. leucofasciatus</i> Liu and Hu, 1962
			<i>R. hui</i> Liu, 1945
			<i>R. gongshanensis</i> Yang and Su, 1984
			<i>R. omeimontis</i> Stejneger, 1924
			<i>R. arvalis</i> Lue, Lai, and Chen, 1995
			<i>R. aurantiventris</i> Lue, Lai, and Chen, 1994
			<i>R. moltrechti</i> Boulenger, 1908
			<i>R. prasinatus</i> Mou, Risch, and Lue, 1983
			<i>R. taipeianus</i> Liang and Wang, 1978
			<i>R. chenfui</i> Liu, 1945
			<i>R. hungfuensis</i> Liu and Hu, 1961
			<i>R. minimus</i> Rao, Wilkinson, and Liu, 2006
			<i>R. nigropunctatus</i> Liu, Hu, and Yang, 1962
			<i>R. yaoshanensis</i> Liu and Hu, 1962
			<i>R. yinggelingensis</i> Chou, Lau, and Chan, 2007
	Microhylidae Günther, 1858	<i>Microhyla</i> Tschudi, 1838	<i>M. mixtura</i> Liu and Hu, 1966
		<i>Micryletta</i> Dubois, 1987	<i>M. steinegeri</i> Boulenger, 1909
		<i>Kaloula</i> Gray, 1831	<i>K. rugifera</i> Stejneger, 1924
			<i>K. verrucosa</i> Boulenger, 1904